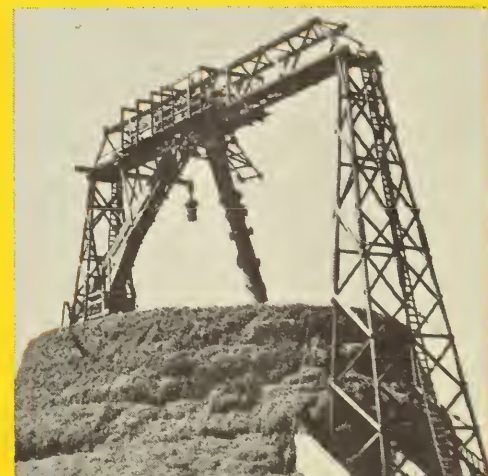




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Publication 1152

April 1962




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GROWING IRRIGATED CROPS IN SOUTHERN ALBERTA

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CANADA DEPARTMENT OF AGRICULTURE

SUCCESSFUL IRRIGATION CROPPING

Though the irrigated areas of southern Alberta comprise only 4 percent of the improved arable land of the province, they produce almost 20 percent of the gross farm revenue. This publication points out many of the important factors in successful crop production under irrigation.

A wide variety of profitable crops are grown in abundance under irrigation. The most common ones are alfalfa, sugar beets, potatoes, pastures, corn, beans, peas, and cereal grains.

Crop rotation is essential in irrigation farming. Crops are arranged in a sequence that maintains or improves the fertility of the soil, helps control erosion, weeds, and other pests, and allows an even distribution of labor and equipment.

Commercial fertilizers are necessary in rotation management. Phosphorus and nitrogen are the most important fertilizer elements in the irrigated area of southern Alberta.

Livestock are an integral part of irrigation agriculture. Many products and by-products of the irrigated farm are fed to livestock and thus marketed as livestock products. Almost three quarters of the fertilizing elements in the feed may be recovered in the manure. Barnyard manure helps to maintain the fertility and structure of the soil.

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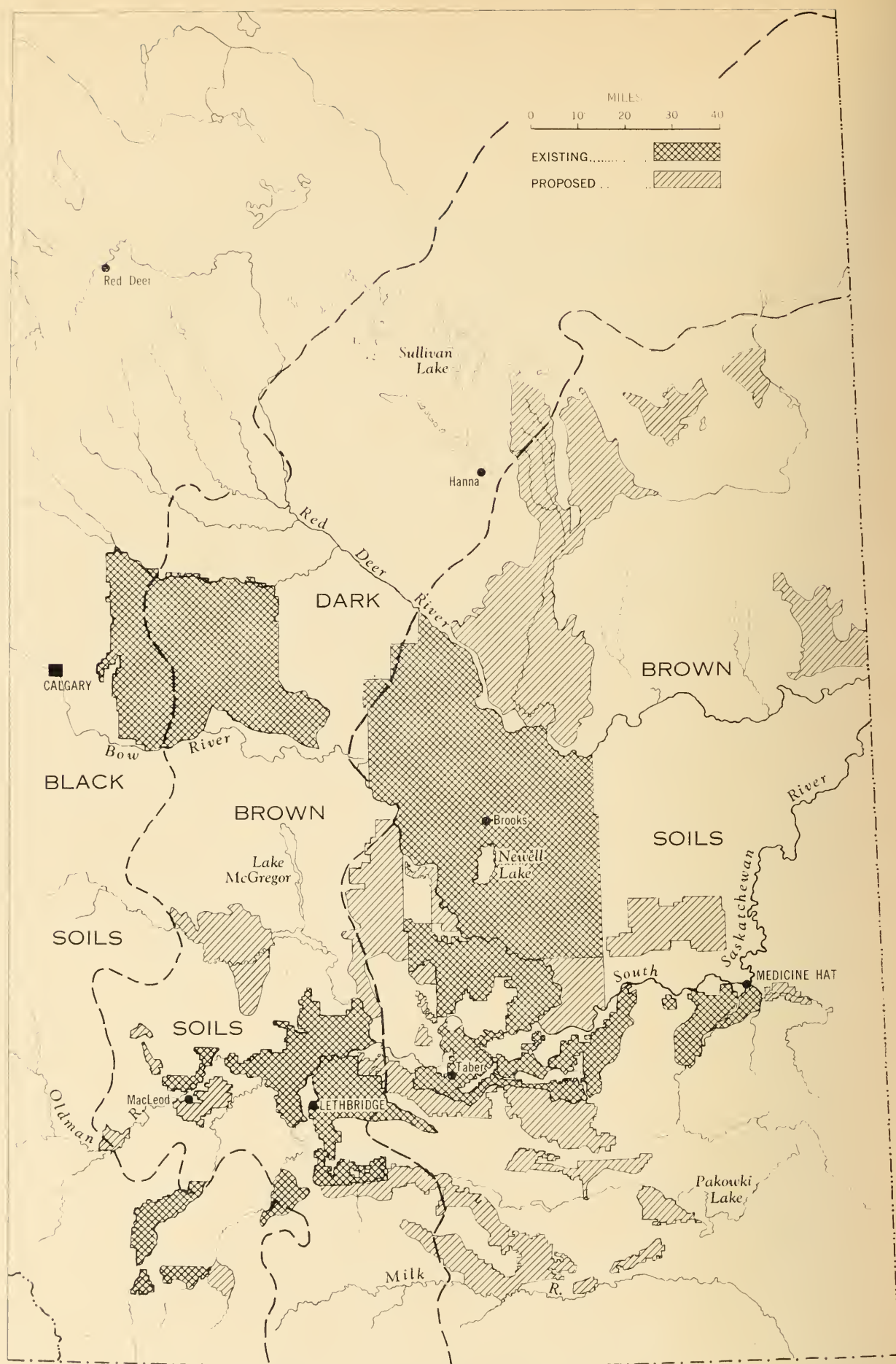


Figure 1.—Map of part of the Province of Alberta showing the areas now irrigated and those for which irrigation is planned.

INTRODUCTION

The irrigated section of southern Alberta (Figure 1) is rapidly becoming one of the most stable agricultural areas of Western Canada. Since organized irrigation began in 1901, a wide variety of profitable crops have been grown here in abundance. Also, the finishing of livestock in feedlots on irrigated farms provides an ideal market for many farm products and by-products, and at the same time conserves or increases fertility of the soil.

Early experience with irrigation in Alberta was discouraging. When there was plenty of rainfall, farmers did not wish to pay for the service; and in dry years, supply facilities were inadequate in peak periods to fill their needs. Wheat was the cash crop and the increases in yields from irrigation seemed hardly worth the effort. A sugar-beet factory established at Raymond in 1903 failed in 1913, partly because of inadequate irrigation. The industry was revived in 1925, and the vegetable-processing industry was established soon after. These industries flourished through the dry 'thirties, when wheat prices were low, and emphasized the importance of irrigation to farmers in the area.

Farming practices on irrigated land have been studied at Lethbridge since 1906, when the Dominion Experimental Station was established here. The irrigated area in Alberta is now about 845,000 acres. Though this is only about 4 percent of the improved arable land of the province, the area produces almost 20 percent of the gross farm revenue. Plans have been made to irrigate another 400,000 acres, and dams and canals now being built will provide water for 50,000 acres of this total.

This publication gives a review of the common agricultural practices in the irrigated area and helpful information from experiments. These experiments were conducted mainly at the Research Station at Lethbridge. Information and suggestions from other Canadian and United States institutions and from many farmers are also given.

For additional information on forage crops, see Canada Department of Agriculture Publication 1132, *Forage Crops for Irrigated Land*.

CROPS

Irrigation permits the growing of a wide variety of crops that are adapted to southern Alberta. Practices are discussed for the profitable production of the following crops: alfalfa, sugar beets, potatoes, cereal grains, pastures, peas, beans, and sweet corn.

ALFALFA

Alfalfa grows well in a dry, sunny climate, on well-drained soil with adequate moisture. It has been grown in Alberta since the beginning of irrigation and is one of the mainstays in irrigation farming in the area.

Seedbed

Alfalfa seed needs a fine, firm, moist seedbed. It is easier to prepare such a seedbed on fall-plowed than on spring-plowed land. For satisfactory irrigation, make sure that the field is level (Figure 2).



Figure 2.—A well-leveled field is irrigated from border ditches.

Fertilizing

Alfalfa needs a great deal of phosphorus. It takes 47 pounds of phosphate (P_2O_5) to produce 4 tons of alfalfa hay but only 26 pounds to produce 40 bushels of wheat.

At the Lethbridge research station, where it has been grown in a 10-year rotation with sugar beets and cereal grains since 1911, alfalfa yields have not been satisfactory unless phosphate fertilizer was applied. The average yields of alfalfa, fertilized and unfertilized, for 27 years were:

Year	Tons per Acre	
	100 lb. 11-48-0 per acre	No fertilizer
First.....	4.2	3.2
Second.....	3.2	1.9
Third.....	2.4	1.9

The fertilizer (11-48-0) was applied in early spring to the first-year alfalfa only.

Many alfalfa fields give low yields in the second and third years and also become badly infested with dandelions. These fields probably lack phosphorus

and are likely to respond to phosphate fertilizer. In general, apply 100 pounds of 11-48-0 fertilizer per acre every other year of hay production to keep the soil well supplied with phosphorus.

Seeding

Under irrigation, alfalfa is seeded either with or without a companion crop. If you sow a companion crop, seed the alfalfa through the grass-seeding attachment of the drill (or in a separate operation) to a depth of not more than 1 inch. Or seed the alfalfa in stubble, preferably barley, either as soon as the grain is harvested in August or very early in the following spring.

Cereals are suitable companion crops and canning peas are excellent. The cereals are sown at lower rates than when sown alone. Wheat is better than oats or barley because it is less dense, but all three are satisfactory.

As a rule, sow 10 pounds of alfalfa seed per acre. If the seedbed is poor, increase the rate.

Irrigation

If you use a companion crop, irrigate to suit the alfalfa. Alfalfa seeded with a cereal crop needs irrigating oftener than the grain alone.

At Lethbridge, the highest yields of hay came from fields that had three 6-inch irrigations: (1) early in May, (2) when the crop was 12 inches high, and (3) immediately after the first cutting. When an application was made the previous fall instead of early in May, the yield was only slightly lower. If the third application is made before, instead of after, the first cutting, the hay may be difficult to cure. Also, the soil may be too wet at cutting time.

Harvesting

Haymaking on irrigated land in a semiarid climate has several advantages. In southern Alberta, much of the hay is in bales or in the stack within four or five days after it is cut. Usually, most of the leaves are still attached. As a result, the original greenness and the high percentages of vitamins and other nutrients are preserved.

Two or three crops of alfalfa per year are usually grown on irrigated land in Alberta. The first is put up in late June or early July and the second about a month later. Often a third crop is available; when harvested in late September or early October, before the frost, this one provides palatable feed of good quality. However, because of the cold weather, it is not as easy to cure as the earlier crops. Also, alfalfa plants that have been cut just before frost arrives may be winterkilled because the root reserves have been depleted.

For best-quality hay, harvest the alfalfa when a tenth to a quarter of the blossoms have opened. If bloom is scarce, gauge the cutting time by the new shoots that develop from the crowns; cut it before these shoots are long enough for the mower to clip them off. To save the leaves, rake the alfalfa into windrows within a few hours after cutting. When the weather is good for drying, rake the hay at cutting time with a side-delivery rake placed right behind the mower.

Alfalfa as a Soil-improving Crop

Land on which alfalfa has been grown for several years is usually in good physical condition. The roots penetrate deeply, aerating the soil and promoting the growth of beneficial bacteria.

Alfalfa may enrich soil, like other legumes, by adding nitrogen from the air. An average crop of alfalfa may “fix” 50 to 100 pounds of nitrogen per acre yearly. Only about a third of this is stored in the roots of the plants. Hence, if alfalfa is cut continuously for hay, the nitrogen content of the soil will not be greatly increased. Indirectly, alfalfa may improve the fertility of the soil if the hay is fed to animals on the farm and the manure is used on the land.

Use Alfalfa to Control Weeds

Vigorously growing alfalfa, cut twice each year for hay, controls Canada thistle, wild oats, and annual weeds. It checks the spread of sow thistle but usually does not eradicate it. It does not control dandelions, but these are not troublesome in a well-fertilized alfalfa field.

Alfalfa can be established in a field where there are patches of Canada thistle, but the surface soil must be kept moist until the young plants are growing well. In a well-managed hay field, the thistles are usually eradicated by the end of the third season.

Alfalfa does not control leafy spurge, Russian knapweed, field bindweed, or hoary cress. Field bindweed, particularly, spreads rapidly in alfalfa. As the seeds are lower than the mower cutter bar, they are not cut off and are later spread over the field by the irrigation water.

Alfalfa's Place in Crop Rotation

To take advantage of its beneficial effect on the soil, sow alfalfa on land that has produced several other crops. You may leave it down for three years or longer if the plants are vigorous. For the greatest benefit, grow it in turn on all your fields.

When you break up the alfalfa sod, sow a cereal grain or peas as the next crop. Potatoes also do well after alfalfa. Small-seeded crops, such as sugar beets, are not recommended after alfalfa because it is difficult to prepare suitable seedbeds for them.

SUGAR BEETS

The acreage of sugar beets grown on irrigated land in southern Alberta has increased from 5,000 acres in 1925 to about 42,000 acres in 1961. It is the most profitable field crop grown here.

Choice of Land

Sugar beets grow well in many types of soil, from heavy clay to sandy soil; under irrigation, loam is the best. They do well in soils with moderate amounts of salts, but not on land with the water table near the surface. In Alberta, the best crops are grown on fertile, weed-free, well-drained land that has a gentle slope to allow thorough, uniform irrigation.

Seedbed

The ideal seedbed for sugar beets is fine, moist, and firm. It contains few lumps, has ample moisture within an inch of the surface, and is so firm that a footprint shows the heel and toe marks but not the instep.

To prepare the land, plow and level it in the fall if at all possible. Then, in the spring, all you have to do before planting is to cultivate lightly to destroy weed seedlings, harrow several times, and pack the soil to pulverize the lumps (Figure 3).

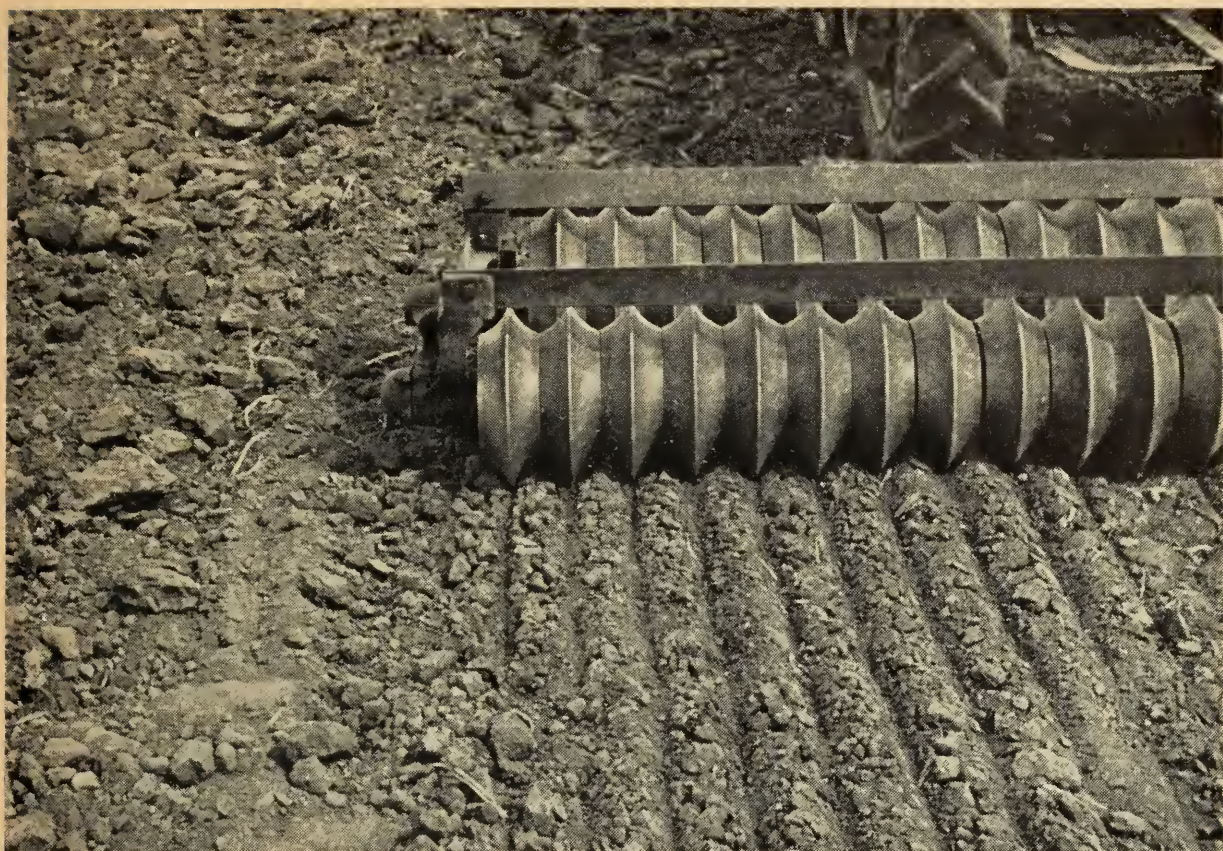


Figure 3.—A cultipacker, or land roller, is an indispensable implement in preparing a fine, firm seedbed.

If you do the leveling in the spring, the low places will get too much loose soil and the high spots will have too little and bake. In many patches the seeds may not germinate. Also, avoid plowing in the spring, especially after row crops. Simply cultivate the land fairly deeply to loosen the soil, then harrow, and pack well to prevent loss of moisture. When land must be spring-plowed, for example, to turn stubble under, be sure to pack it well; also, pulverize the lumps except on light soils where there is risk of drifting.

Fertilizing

For high yields, sugar beets need plenty of nitrogen and phosphorus. If you grow sugar beets after a legume crop, the soil probably has enough nitrogen in it. For phosphorus, however, you must add a commercial fertilizer. As a general rule, apply 100 pounds of ammonium phosphate (11-48-0) per acre at the time of seeding sugar beets.

Barnyard manure is an excellent source of nitrogen. In the beet-growing areas of Alberta, nearly all the available manure is applied before seeding sugar beets. The application of manure is discussed later in this publication (page 21).

If the sugar beets do not follow a legume or if you do not apply barnyard manure, you will need to use a commercial nitrogen fertilizer. Apply 50 to 70 pounds of nitrogen per acre in either the fall or early spring before seeding. Work it about 4 inches into the soil. Some farmers prefer to apply the nitrogen as a side-dressing after thinning the sugar beets. This way, apply it 4 to 6 inches from the rows and work it in 3 to 4 inches deep. Apply it early, before the first week in July, so that the plants can make the most use of the fertilizer.

In order to germinate, sugar beets must take up about one third of their weight in water. If the moisture in the soil is low, germination will be delayed or prevented. Highly soluble fertilizers, such as nitrogen fertilizers, readily absorb moisture from the soil. When a large quantity of nitrogen fertilizer is near the seed, some of the moisture is taken up by the fertilizer and is not available to the seed. Do not place nitrogen fertilizer near the seed but broadcast it and work it into the soil before seeding or apply it as a side dressing later.

Seeding

Sugar-beet seed is supplied to the grower by the contracting company. The seed used in Alberta is grown on the west coast of British Columbia.

There are two types of seed. Multigerm seed, the more common, contains one to five germs, each capable of producing a plant. Monogerm seed has only one germ.

In Alberta, most farmers use decorticated seed, which is a processed multi-germ seed. Monogerm varieties are still being improved, and there is a gradual increase in the acreage sown with this seed.

Row-crop drills used in southern Alberta seed four or six rows at one time, and the rows are spaced 22 inches apart. For decorticated seed, sow 6 to 7 pounds per acre (about 10 seed pieces per foot) and drive no faster than $2\frac{1}{2}$ miles per hour. Plant 1 to $1\frac{1}{2}$ inches deep and make sure that the seed is covered carefully and firmly.

To get a good yield of beets with high sugar content, seed as early as possible. The maximum growing season for sugar beets in Alberta is five months. The seedlings are susceptible to frost for a few days after they emerge; once they develop true leaves they are more resistant.

Beets were seeded on various dates from April 20 to June 10 at the Lethbridge research station. The average yields for six years (1931-36) were as follows:

Date of seeding	Yield (tons per acre)
April 20	21.1
May 1	19.6
May 10	20.7
May 20	18.1
June 1	14.6
June 10	12.7

It was planned to seed on April 10 also, but it was not possible to do this in three of the six years; however, when seed was sown on April 10, yields were as high as for any other date.

Thinning and Weeding

The best yields of sugar beets are obtained when there are about 25,000 plants per acre. This means that in rows that are 22 inches apart you should leave plants about 1 foot apart within the row.

If you thin by hand, begin as soon as the seedlings have four true leaves. Instruct the thinners to leave 100 plants in 100 feet of row.

Rotary thinners are generally used now, instead of harrows and finger weeders, for thinning and weeding in the rows. After estimating the stand of

beet seedlings (usually 20 to 30 inches out of 100), use the proper size of knives on the rotary heads of the thinner to remove surplus plants. Repeat with another size of knife if necessary.

When the stand is poor (for example, when there are only 40 to 65 plants in 100 feet of row after thinning), reseeding is not usually recommended. In experiments in Colorado, 50 percent stands of beets that had been planted at the right time gave the same yield as a field that had been reseeded to make a 98 percent stand.

Irrigation

Sugar beets need a great deal of water throughout the growing season. At the Lethbridge research station, land that receives three or four irrigations during the season, plus one the previous fall, gives the highest yields of beets.

Begin irrigation soon after thinning and repeat about every three weeks so that the soil is always moist. Time the last irrigation to leave the soil moist for harvesting. This makes digging easier, increases yields, and improves the storing quality of the beets.

Harvesting

The longer you can delay harvest safely, the higher the sugar content of the beets will be. Beets dug at Lethbridge on October 23 contained 30 percent more sugar than those harvested on September 29.

Speedy, efficient machines now dig, top, and load sugar beets at harvest time. In 1959, about 82 percent of the Alberta crop was harvested mechanically. Also, the cost of mechanized harvesting is only 65 percent of that for hand labor.

Transplanting

At the Lethbridge research station, sugar-beet seedlings transplanted to the field in May yielded 4 to 9 tons more per acre than beets seeded in the field on the same day. The transplants were sown in a hotbed early in April.

The first commercial ventures in sugar-beet transplanting in southern Alberta were not successful. With more experience, however, transplanting may become an accepted practice.

POTATOES

Potatoes do well under irrigation and are a good cash crop. The acreages grown in southern Alberta vary greatly from year to year. This is because the potatoes are not grown under contract and the quantity planted depends on the prospective market.

As an irrigated crop, potatoes have several advantages. They give good weed control, because a potato field needs to be well cultivated. They suit crop rotations, particularly before sugar beets or cereal grains. The culls can be fed to livestock. Further, potatoes are not planted until the rush of seeding other irrigated crops is practically over.

Choice of Land

Although potatoes grow best on loam or sandy loam, heavier soils are satisfactory if they are fertile and carefully prepared. The ideal land is well drained and has a gentle slope (1 to 2 inches of fall per 100 feet) to allow thorough, uniform irrigation.

Because potatoes need soil with plenty of organic matter, in a rotation they usually follow a sod crop or a green-manure crop. Too much decomposed organic matter in the soil, however, favors the organisms that cause scab. For this reason, when manure is needed on the land apply it during the season before the potatoes are planted.

Seedbed

The ideal seedbed for potatoes is deep, mellow, moist, and free from weeds. Plow the land during the summer or fall before planting. If potatoes follow alfalfa, plow under the second crop of alfalfa in August, cultivate well, and irrigate. Before planting potatoes in the spring, cultivate the land 5 to 6 inches deep to destroy weeds and to mellow the soil; then pack it well to preserve moisture.

Fertilizing

In southern Alberta, use of 100 pounds of ammonium phosphate fertilizer (11-48-0) per acre on the heavier soils increases potato yields. On lighter soils, additional nitrogen is needed. Apply the ammonium phosphate at planting time on both sides of the rows and a little deeper than the seed pieces. Nitrogen fertilizer, if used, should be broadcast and worked into the soil before planting.

Planting

Select, treat, cut, and handle seed as described in Canada Department of Agriculture Publication 918, *Potato Growing in Canada*. Protect the sets from drying and injury. A good rule is to cut, treat, and plant the potatoes on the same day. If this is not possible, follow the directions in Publication 918 for healing the surfaces of cut potatoes to keep them from rotting.

Plant potatoes in rows 36 inches apart, using one- or two-row mechanical planters operated at moderate speed. Place the seed pieces about 12 inches apart and 3 to 4 inches deep in warm, moist soil. If the seedbed is very fertile, place them closer together; if it is poor, place them farther apart.

The quantity of seed needed depends on the size and spacing of sets and the number of rows per acre. For 1½-ounce pieces (usually the best size to use) 12 inches apart in rows 36 inches apart, you need about 23 bushels of seed per acre; for 2-ounce pieces, about 30 bushels.

Cultivation

Careful, timely cultivation eliminates the need for hand hoeing. Begin cultivating the potato field as soon as weed seedlings appear. You may harrow several times before the potato plants emerge if the field has been properly prepared. A finger weeder is also effective for weed control, both before and after the plants are up.

As soon as the rows of plants are visible, start using a cultivator to throw the soil toward the rows to smother small weeds. As the plants grow, push more soil into the rows, building up hills and leaving furrows for irrigating. In medium to heavy soil make deep, narrow furrows so that soil near the tubers will not be saturated during irrigation; in sandy soils make the furrows shallower and wider, to bring water closer to the plants.

Irrigation

For highest yields and best quality, potatoes need to be kept growing vigorously from the time they emerge until shortly before harvest. Irrigate when the fields show signs of drying but before the plants start to droop. When the soil

is too dry during the first few weeks, the potato vines and leaves stay small; when it is too dry during tuber formation, fewer tubers are formed and these, if irrigated later on, may grow into large, rough potatoes.

Irrigate potatoes by running small streams of water down the furrows. How long to leave the water running at one time depends on several factors, such as the rate of percolation, the slope of the land, the amount of moisture in the soil, and the stage of plant growth. Irrigate lightly and often to keep the surface layers of the soil moist; potatoes get over half of their water from the top 12 inches of soil and over three quarters from the top 24 inches. At the Lethbridge research station, on medium-loam soils, light irrigations are needed about every three weeks while potatoes are growing vigorously. Lengthen or shorten this period to compensate for rains or very dry spells. Time the last irrigation to leave the soil moist for harvesting.

Harvesting

Harvest potatoes early enough to avoid frost damage. Destroying the vines mechanically or with chemicals hastens maturity and also lessens the risk of damage to the potatoes during harvest.

Run potato diggers deep enough to pick up sufficient soil on the digger chain to cushion the potatoes and keep them from being bruised. Leave the potatoes on the ground for an hour or two to dry and harden the skins a little; this eliminates much subsequent cracking and scuffing.

Careful handling is necessary throughout the harvesting operation. Fill picking bags only partly full, use padded truck boxes, and never dump the potatoes into the storage cellars.

CEREAL GRAINS

On irrigated farms in southern Alberta, cereal grains are grown primarily for feed. Soft white spring wheat, for pastry flour, is grown on a rather large scale, and some grain is grown for registered seed.

Of the three cereals grown for feed, barley yields more per acre in feed value (total digestible nutrients) than either wheat or oats. The feed value of 50 bushels of barley equals that of about 40 bushels of wheat or 80 of oats. On a well-balanced irrigated farm it is usually good practice to grow some of each of these cereals. Usually, more barley is grown than wheat or oats.

Seeding

Cereals are sown at slightly higher rates on irrigated land than on dry land. As a rule, sow $1\frac{1}{2}$ bushels of wheat per acre, $2\frac{1}{4}$ of barley, and 3 of oats.

Irrigation

In southern Alberta one application of about 6 inches of water is often enough to produce a good grain crop. At the Lethbridge research station, wheat yielded slightly more after either three irrigations (at the five-leaf, shot-blade, and flowering stages) or two irrigations (at the five-leaf and flowering stages) than after one at the shot-blade stage. Irrigation should be started before soil moisture becomes limiting; in these tests irrigating as early as the three-leaf stage, before the plants shaded the ground, had no detrimental effect on the crop.

Barley and oats often lodge if irrigated after the grain is in head. This is why some farmers grow wheat rather than barley for feed.

GREEN MANURE

A green-manure crop is one that is grown for plowing under to improve the soil. Legume crops are often used because they are able to take nitrogen from the air and add it to the soil. Elements other than nitrogen are not added to the soil by growing green-manure crops. The minerals necessary to grow a green-manure crop come from the soil. When the crop is turned under, these elements will be returned to the soil, perhaps in a more usable form.

Green-manure crops add organic matter to the soil. The plant material of the growing crop is manufactured from the carbon dioxide of the air and the mineral elements and water of the soil. When a crop is turned under, this organic material is added to the soil. A single green-manure crop, however, does not add enough organic material to greatly improve a soil seriously deficient in organic matter.

A green-manure crop may improve the structure of the soil by improving aeration and by providing binding material for the soil particles.

Because they increase soil nitrogen, legume crops such as sweet clover, alfalfa, and peas are the most common green-manure crops. Cereal crops are sometimes used for adding organic matter but they add no nitrogen to the soil.

To get the most out of a green-manure crop, plow it under when it is succulent and keep the soil moist to promote decomposition.

Sweet Clover

Sweet clover is the most important green-manure crop in southern Alberta. Usually it is seeded in the spring with wheat or another cereal; in June of the following year the green clover, in the bud stage, is plowed under. The land is irrigated and then fallowed for the rest of the season. During this time the green manure thoroughly decomposes, and the succeeding crop benefits from the abundance of readily available nutrients.

This practice has one great disadvantage: there is no revenue from the land for one full season. To overcome this and still benefit from green manure, in districts having a growing season long enough, the crop is plowed under in late spring and the land is then seeded with a paying crop. This can be done in southern Alberta but the succeeding crop must be selected carefully. At the Lethbridge research station, after clover was plowed under in May, canning corn produced a profitable crop. Also, yields of beets grown on this land the next year were almost as good as those of beets grown on comparable plots fallowed for the full season the year before.

VEGETABLES AND SMALL FRUITS

Vegetables and fruits are grown under irrigation for processing—canning and freezing—and for selling as fresh produce. A few are also grown for seed. The acreage of these cash crops in southern Alberta is not large in comparison with that of other cash crops but it is increasing. In some areas fruit and vegetable crops help to stabilize the farmer's income because they are grown as alternatives to other cash crops that may be overplentiful in some years.

Peas, sweet corn, string beans, and field beans are the main processing crops grown under irrigation. Other special crops grown are asparagus, beets, cabbage, cantaloupes, carrots, cucumbers, muskmelons, pumpkins, raspberries, strawberries, sunflowers, tomatoes, and turnips.

PEAS

Peas are grown for canning and freezing and for seed. In addition, they yield about 2 tons of hay or 5 to 6 tons of ensilage per acre, providing a by-product that is a valuable livestock feed.

Peas fit very well into an irrigated crop rotation, and the crop that follows them usually does well.

Choice of Land

A good crop of peas may be grown on land that produced cereal grain the year before, if weeds are no problem; peas do not compete well with weeds. Chemicals such as MCPA and MCPB help control broad-leaved weeds in peas, with little or no damage to the crop. Peas for processing are often grown after alfalfa in a rotation since volunteer alfalfa is not a problem in this crop and the land remains fertile for the next crop.

Seedbed

When preparing the seedbed for peas, work the land well and level it to favor even germination and aid in irrigation. This promotes uniform maturing of the crop and, in turn, increases the cash returns.

Fertilizing

Fertilizers may damage germinating peas and should not touch them. As a rule, drill 80 to 100 pounds of 11-48-0 per acre into the seedbed one week before seeding. Peas respond to careful manuring but heavy applications promote growth of vines rather than seed pods.

Seeding

Treat the seed with a fungicide (usually mercury dust) before planting. Sow $2\frac{1}{2}$ to 3 bushels of seed per acre. Drill it into warm, moist soil, to a depth of about $1\frac{1}{2}$ inches and no deeper than 3 inches. Seed may rot if left too long in soil too cold for germination.

Irrigation

Peas need plenty of moisture from the time they are planted until shortly before harvest. Uniform irrigation is essential; unirrigated spots, and low areas filled with water, produce no peas.

At seeding time make sure that the land has enough moisture to germinate the seed and bring the plants to a height of 6 to 8 inches. Irrigate processing peas at this stage, as the ground is shaded and the young plants respond well to added moisture; and irrigate again shortly before harvesting the crop. Irrigate field peas when the plants are 8 inches high, and again in late July; but apply no water to them for four to six weeks before harvest as this delays maturity.

SWEET CORN

Sweet corn is grown for canning and freezing. The average yield on irrigated land in southern Alberta is $4\frac{1}{2}$ tons per acre, but yields up to 8 tons are common. In warm weather the sugar in corn kernels changes rapidly to starch, lowering the quality and the cash returns for the crop. For this reason corn must be delivered to the processing plant as soon as possible after picking.

Choice of Land

Corn grows well on almost any type of soil but matures earliest on well-prepared, light, sandy loam. The yield depends on the fertility of the soil. Corn does well after alfalfa, sugar beets, or peas. However, in irrigated farm rotations corn is probably better suited than other crops to follow a cereal grain.

Seedbed

Since corn is a large-seeded crop it does not need as fine a seedbed as many other crops. Prepare a firm, moist seedbed. Till the land to destroy weed seedlings, and level it for uniform irrigation.

Seeding

Because corn seed may rot in cold soil, do not plant it until the soil has warmed up; at Lethbridge, this is usually early in May. Corn planted at the end of May also gives satisfactory yields. In this area, the machinery used for seeding and cultivating sugar beets is also used for corn.

Sow corn in rows 22 inches apart, dropping about two kernels per foot of row so that there will be at least one plant per foot in the final stand. Plant the seed 1 to 3 inches deep in moist soil; shallow planting speeds up germination and also reduces the risk of rotting.

Cultivation

On irrigated farms, corn is considered a crop for getting rid of weeds and so needs careful cultivation and sometimes hoeing. Harrow the fields to destroy small weeds that come up before the corn and, when the corn is 3 to 4 inches high, harrow again if necessary. Do the second harrowing lengthwise along the rows so that the corn stalks are not pulled out. This cultivation should control weeds unless they are unusually persistent.

Selective sprays like 2,4-D amine are helpful in controlling weeds in corn. Triazine compounds, such as simazine and atrazine, control annual weeds but these, particularly simazine, may harm crops that follow the corn.

Irrigation

On a hot, windy day an acre of corn uses $\frac{1}{2}$ acre-inch of water. Apply water before the soil gets too dry. On medium-textured soils, irrigate when the plants are 1 to 2 feet high and again near the silking stage. Make a final application a few days before picking to improve the yield and quality of the crop.

Stover for Silage

The corn plants remain green and succulent for a while after the ears are picked and make good-quality silage. The stover contains high percentages of sugar and protein, and silage made from it is almost as good as that made from whole plants of field corn, including the ears.

To prepare the stover quickly and cheaply, use a traveling ensilage cutter. This leaves the land clean and easy to work into a new seedbed in the spring.

If you do not ensile the stover, plow it under in the fall and pack the soil well. Irrigate, if necessary, to provide enough moisture for decomposition.

Some growers pasture off their corn stover. However, this provides much less feed than silage because the leaves and stalks soon become brown, dry, and unpalatable. Also, the stalks left standing over winter are hard to work into the soil in the spring and keep the seedbed loose and open.

BEANS

Though beans are very sensitive to frost, large quantities of string beans for canning and freezing, and of field beans, are grown in Alberta. The beans are of excellent quality and yields are high. Beans are also important in crop rotations. In tests at the Lethbridge research station, crop yields were higher after beans than after any other crop.

Choice of Land

Well-drained, alkali-free land with a uniform slope is best for growing beans. They do not grow well on wet soil and have very little tolerance to salt.

Seedbed

Prepare a firm, moist seedbed and level it well to promote uniform germination and irrigation.

Fertilizing

Fertilizers reduce germination if they touch bean seeds, so most growers broadcast or drill the fertilizer (100 pounds of 16-20-0 per acre) into the seedbed a week before seeding. If you have the necessary equipment you may apply it at seeding time about 2 inches to the side and slightly below the seed.

Seeding

Sow beans in rows 22 to 28 inches apart in warm, moist soil about mid-May. Plant them about 1 inch deep in heavy soils and as deep as 2 inches in the lighter ones. Sow 50 to 70 pounds of seed per acre, using the lower rate for smaller seed.

Early germination and rapid, continuous growth are as important for beans as for peas; the seed may decay if it is left too long in cool, moist soil, and the seedlings that do grow are more susceptible to diseases and insects.

Treating the seed with an insecticide, preferably aldrin, dieldrin, or heptachlor, helps control wireworms. Do not use mercurial treatments on inoculated seed as these kill the live bacteria in the inoculant.

To avoid a build-up of injurious diseases, and possibly insects, do not grow beans on the same land two years in succession.

Cultivation

When the plants are small, use a harrow or a rotary hoe along the rows. Cultivate close to the row and hill the soil to cover small weeds.

Beans are shallow-rooted and deep cultivation damages the roots. Cultivate only as deep and as often as necessary to control weeds and try to avoid cultivating after the blossoms appear. Also, do not cultivate when the leaves are wet as this may spread disease.

Some of the newer herbicides show promise for weed control in beans.

Irrigation

Beans need enough moisture to keep growing vigorously but too much may delay maturity. Three irrigations are usually enough for field beans: one in the fall before planting, one in late June, and another in late July. Irrigate string beans similarly and, in addition, apply a light irrigation after each picking.

PASTURES

With the continuing extension of irrigation and the need for only limited acreages of contract crops, many farmers now include irrigated pastures in their livestock programs. These pastures are as profitable as sugar beets or other specialty crops grown under irrigation. For example, an acre of good pasture can provide grazing for three yearling steers for 120 days. This should result in the production of 700 pounds of beef per acre.

Choice of Land

Because it is beneficial for land to be left in sod a few years, the irrigated pasture should be a part of the farm rotation. For the greatest benefit, pasture all your fields in turn.

Seedbed

Pasture grasses and legumes need a fine, firm, moist seedbed. Pack the seedbed well with a cultipacker and, for uniform irrigation, make sure that the field is level. Good results have been obtained by seeding directly into clean stubble without working the land first.

Fertilizing

For high yields, grasses need phosphorus and a good deal of nitrogen. Apply 100 pounds of ammonium phosphate, 11-48-0, and 50 pounds of nitrogen per acre as a top-dressing in early spring. Apply 50 pounds of nitrogen per acre in June and again in July.

Seeding

Pasture mixtures of orchard grass, brome grass, creeping red fescue, and Ladino clover are used in southern Alberta. Consult your district agriculturist for the best mixture to use in your area.

Drill seed half an inch deep into a firm seedbed. Shallow seeding is important for good germination and dense stands.

The use of a companion crop with pasture grasses has both advantages and disadvantages. A companion crop aids in weed control, provides revenue from the land while the pasture is being established, and protects the soil against erosion until the turf forms. However, grasses may give higher yields the first year and produce better stands without a companion crop.

Wheat, oats, and barley are all satisfactory companion crops but wheat is the best. If you use a companion crop, sow it at about half the normal rate.

Irrigation

For lush, rapidly growing pasture in Alberta, grasses need about 15 inches of supplementary water per season. This is usually applied in four or five irrigations.

Moisture needed for seed germination has to be near the surface of the soil. If irrigation is necessary, apply it before, not after seeding, unless sprinklers are available. Sprinkler irrigation is ideal for pastures since the water can be applied oftener and in lighter amounts than by the usual methods.

Paddocks are irrigated as soon as the stock are removed after grazing. Rotational grazing makes it possible to irrigate a paddock and still give the surface soil time enough to dry before the stock are turned in again.

Pasture Management

Rotational grazing is the most profitable way of using pasture. Divide each field into a series of paddocks and move the livestock from one to another so that they are always grazing relatively young, succulent grass. When the grass is growing most rapidly there may be more than the animals need. If this happens, cut one or two of the paddocks for hay or silage.

As a rule, do not graze the pasture in the seeding year because the seedlings may be injured by trampling or close grazing. Occasionally the companion crop is grazed to advantage, but this requires careful management.

CROP ROTATION

A true rotation has a regular schedule of crop sequence and acreages and each field grows each crop at regular intervals. If acreage or crops vary from year to year, it is not a true rotation.

A good illustration of a true crop rotation is Rotation U at the Lethbridge research station. This 10-year rotation consists of 10 one-acre plots. The crops for the various years are as follows: 1st, barley; 2nd, oats and alfalfa; 3rd-5th, alfalfa; 6th, sugar beets; 7th, wheat and alfalfa; 8th-10th, alfalfa. The rotation has been followed continuously on this tract of land since 1911. The fertility of the soil has been increased in this rotation, and the crop yields are much higher than the district average. Rotation U does not meet the needs of all irrigation farmers. To have 60 percent of the farm growing alfalfa each year and only 10 percent producing a valuable cash crop (sugar beets) is not always practical.

The Ideal Crop Rotation

The ideal crop rotation includes maximum acreages of the most profitable crops. The crops are arranged in a sequence that maintains or improves the fertility of the soil, helps control erosion, weeds, and other pests, and allows an even distribution of labor and equipment. It also helps to distribute risks and allows more accurate forecasting of annual returns. However, a fixed rotation has some disadvantages: it lacks flexibility; some relatively unprofitable crops must be grown; and it is inconvenient to have a number of small fields that may need temporary fencing.

A good rotation is difficult to design, and often compromises are necessary. Because hay and pasture crops are usually grown for a number of years at a time, perhaps it is better to exclude these from the rotation. A true rotation can be conducted on part of the farm and a planned crop sequence on the rest. For example, the owner of one irrigated farm, a quarter section, uses four 20-acre fields for a four-year rotation and seven 10-acre fields for a planned sequence. In the rotation he grows sugar beets, barley and sweet clover, canning corn, and canning peas; in the planned sequence, alfalfa (20 acres, 10 acres seeded annually with a cereal crop), cereal crops (30 acres), sugar beets (10 acres), and canning peas (10 acres). The total grown each year is 30 acres of sugar beets, 30 acres of canning peas, 20 acres of canning corn, 20 acres of alfalfa, and 50 acres of cereal crops.

Successful irrigation farming depends a good deal on the application of manure to the land, especially before crops such as sugar beets. Therefore, the farmer using the above plan sells only the green peas and corn ears for canning, and the refined sugar from the sugar beets. He feeds the remainder, including

the sugar-beet pulp, to his own livestock so that it is returned to the land as manure. These crops provide 100 days' feed for 1,300 lambs, which produce about 300 tons of manure, or 10 tons of manure for each of the 30 acres of land for sugar beets.

Order of Crops in the Rotation

In a rotation the most remunerative crop is usually given the best place in the sequence: it follows the crop that leaves the land in the best condition. Most crops do well after legumes, such as beans and peas, because these enrich the soil with nitrogen. Peas are better than beans when manure is to be applied before the next crop.

Barley and sugar beets both leave the land in poor condition. Since the yields of wheat and canning corn are affected least by the preceding crop, one of these usually follows sugar beets or barley.

Summer-fallowing has no place in irrigation farming except when weeds are a serious problem or when the land is being leveled. Some farmers fallow their fields because they may get 2 to 4 tons more per acre of sugar beets the next year. Perhaps they forget that a crop grown after fallow really covers two years' operations and that the larger yield is not as profitable as it seems.

LIVESTOCK

The fertility of irrigated land cannot be maintained economically without the application of manure. For this reason it is essential to have some kind of livestock on most irrigated farms.

A farmer who continually sells all the crops he produces steadily reduces his reserves and sooner or later finds that his soil-fertility bank account is overdrawn. Three tons of alfalfa hay, which may be produced on 1 acre, contain 140 pounds of nitrogen, 35 of phosphoric acid (P_2O_5), and 135 of potash. This is worth about \$26 in commercial fertilizer.

But when the crops or their by-products (sugar-beet pulp, pea vines, etc.) are fed to livestock, almost three quarters of the fertilizing elements in the feed may be recovered in the manure and can be returned to the land. The animals also provide extra income for the farmer by converting raw crops into salable products such as meat, milk, eggs, and wool. Selling these products does not decrease the soil fertility nearly as much as selling the crops; for example, a whole carload of two-year-old fat steers contains less phosphorus than 400 bushels of wheat.

MANURE

Besides being an excellent fertilizer, manure improves the structure of the soil and increases its water-holding capacity. It lightens a heavy soil and helps to bind a light one together, making the soil less susceptible to water erosion. It favors growth of microorganisms in the soil and adds vitamins, hormones, and many trace elements, such as boron and iron, which growing plants need in minute quantities.

Bedding

Cereal straw used as bedding adds valuable organic matter to fresh manure. It also absorbs the urine, which contains a good deal of nitrogen and other

fertilizing materials. If too little bedding is provided the urine runs off and these elements are wasted; too much bedding makes the manure strawy and hard to work into the soil.

The weight of straw to use for bedding is about a quarter of the dry weight of the feed. For cattle this is about 8 pounds of straw a day per head, or $2\frac{1}{2}$ to 3 tons per week for 100 steers.

An acre of irrigated wheat produces about $1\frac{1}{4}$ tons of straw; oats produce a little more and barley a little less. Oat straw is the most absorptive; it can take up and hold as much as two and a half times its weight of water.

A hundred steers on full rations in a well-bedded feedlot provide over 300 tons of good manure in five months. This is about twice the weight of the feed eaten. Feedlot lambs produce less manure per pound of body weight than cattle but the manure is drier and has more fertilizer value per ton.

Care of Manure

To retain the valuable fertilizing elements in manure, you must take proper care of it until it is spread on the land. Be sure that gutters or feedlot floors are tight enough to hold the urine until the bedding absorbs it. Try to avoid leaching which sometimes occurs in an open feedlot after a rainstorm. Keep the manure moist and compact to exclude air, and keep it as cool as possible.

Fortunately, winter finishing of livestock in open corrals, as done in the irrigated areas of Alberta, is a rather good way of conserving the manure. Plenty of bedding keeps the lot reasonably dry and the fresh manure mixes into the straw easily. The manure mass is kept firm by constant trampling of the livestock over the whole feedlot and the limited amounts of rain and snow keep it just moist enough.

Application of Manure

Rates.—There is usually a shortage of manure in irrigated areas that are farmed intensively. Consequently, most farmers apply all that they can get to the most responsive cash crop in the rotation. In Alberta, the rate of application of manure to a crop like this varies from 8 to 20 tons per acre. Nearly all crops give higher yields per ton of manure with light dressings than with heavy ones; if you have only 100 tons of manure it is better to apply 10 tons per acre to 10 acres of land than 20 tons per acre to 5 acres.

Two or 3 tons per acre per year is a practical rate of application of manure for the whole farm. To accomplish this, apply 8 to 12 tons of manure per acre to a quarter of the farm each year, or 10 to 15 tons per acre to a fifth of it. Keep in mind that this is not enough manure to keep the land fertile, but if, in addition, you follow suitable cropping practices and use legumes, green manures, and commercial fertilizers, your land should remain highly productive.

Time to apply.—Because the growing season is so short in Alberta, it is best to apply manure in the late summer when this is possible. Summer fallow or land on which canning peas or an early cereal has been harvested is often available at this time. If canning peas precede sugar beets in the rotation, apply manure to the pea stubble in August and plow it under right away (Figure 4).

It is wasteful to spread manure on land during the winter because the nitrogen escapes into the air.

You can get good results by applying well-rotted manure to land in the early spring if you plow it under as soon as possible, wait a few weeks before



Figure 4.—Plowing under well-rotted manure in early fall provides a fertile field for the next crop.

seeding, and make sure that the seeded crop has plenty of moisture. Strawy manure tends to hold back the crop because, during decay, it uses up some of the nitrogen and moisture needed by the seedlings.

Though manure may be spread on pastures any time during the grazing season, apply it in the spring, if possible, so that the spring rains may carry the nutrients down to the roots. Except on pasture and hay crops, always plow manure under as soon as it is spread.

Reinforcement of Manure

Barnyard manure contains much more nitrogen than phosphorus. To improve the balance, superphosphate is often added to manure, at $\frac{1}{4}$ pound of superphosphate per 1,000-pound animal per day. Scatter this in the stable gutters or over the feedlot. It may also be mixed with the manure in the spreader as it goes to the field.

Besides adding needed phosphorus, superphosphate reduces the loss of nitrogen from the liquid manure. Also, adding the fertilizer this way instead of directly to the soil makes the phosphorus more readily available to the plants and eliminates the risk of burning the germinating seedlings with fertilizer.

Residual Value of Manure

In an eight-year rotation at the Lethbridge research station, 30 tons of manure per acre were applied to one series of plots in the fall of 1951 and none to the second. The average yields per acre were higher in the manured plots for at least seven years, as follows:

Year	1952	1953	1954	1955	1956	1957	1958
Crop.....	Beets Tons	Beets Tons	Wheat Bu.	Wheat Bu.	Alfalfa Tons	Alfalfa Tons	Alfalfa Tons
With manure.....	21.3	15.2	50.6	48.3	3.8	4.7	4.6
Without manure...	13.9	10.1	47.6	44.6	2.5	2.0	1.1

Smaller amounts of manure have shorter residual benefits, but 10 tons per acre have given increased yields for as long as four years.

From a farmer's point of view, a ton of manure is worth the increased profit it gives him from a higher yield, less the cost of application. Table 1 shows the value of manure applications on irrigated crops over a long period. The increased profit was \$347.06 from 30 tons of manure, or \$11.57 per ton.

For more information on manure, write to the Information Division, Canada Department of Agriculture, Ottawa, for a copy of Publication 868, *Manures and Compost*.

TABLE 1.—Returns from Manure on Basis of Increased Yield in an Eight-year Rotation on Irrigated Land at the Research Station, Lethbridge, 1929-58

Year	Crop	Average yield ¹ per acre		Increase due to manure	Value of increase (1958 prices)
		With manure ²	Without manure		
First	Sugar beets	20.8	13.7	7.1	\$122.56
Second	Sugar beets	19.9	15.5	4.5	68.17
Third	Wheat	55.0	51.4	3.6	5.76
Fourth	Wheat seeded with alfalfa	51.4	45.4	6.0	9.60
Fifth	Alfalfa	4.0	2.6	1.4	31.24
Sixth	Alfalfa	4.0	1.9	2.1	45.23
Seventh	Alfalfa	3.6	1.5	2.1	46.42
Eighth	Wheat	42.0	30.7	11.3	18.08
Total from 30 tons of manure					\$347.06

¹Yields of sugar beets and hay in tons and of grain in bushels.
²30 tons of manure per acre were applied once every eight years in the fall before the first crop of sugar beets.

COMMERCIAL FERTILIZERS

Although more than a dozen chemical elements are indispensable to plant growth, nitrogen, phosphorus, and potassium are commonly known as the fertilizing elements. When buying commercial fertilizers, be guided by the guaranteed analysis, which must be marked on every bag. Calculate the cost per pound of nitrogen, phosphorus, and potassium and buy them in the cheapest form.

Consult your district agriculturist on specific problems in choosing commercial fertilizers.

Commercial Fertilizers Are Only Supplementary

Commercial fertilizers provide necessary plant food but in no way compensate for poor husbandry. They do little to improve an alkali soil or a poorly tilled one. They cannot replace manure, nor indeed can manure economically replace commercial fertilizers where certain elements are needed. Even if you apply all available manure to your crop lands, the fertilizing elements removed by the crops will probably outweigh the amounts added in the manure. Usually, the cheapest way to make up the shortage is to apply commercial fertilizers.

Irrigated Prairie Soils Need Phosphate Fertilizer

Experiments have shown that the irrigated soils of Alberta need phosphate fertilizer. Applications of 100 pounds of 11-48-0 fertilizer per acre of sugar beets or alfalfa often increase the yield by 25 percent.

Nitrogen Fertilizer Helps Some Crops

Grasses and cereal crops require some phosphate fertilizer, but their greatest yield increases are obtained from nitrogen fertilizers. The yields of such crops as sugar beets, potatoes, and canning corn have also been increased with nitrogen fertilizer. Sandy soils and those that have not grown a legume crop or received barnyard manure are most likely to need nitrogen fertilizer.

High rates of nitrogen fertilizer may reduce germination of some seeds, especially if the soil is dry. When these higher rates are used, broadcast the nitrogen and work into the soil before seeding.

Prairie Soils Are Rich in Potash

In tests on irrigated land in Alberta the addition of potash fertilizers has not increased crop yields. Nevertheless, calculations indicate that an average 160-acre farm loses about 6,000 pounds of potash a year. Though it is only a matter of time until extra potash will be needed in the soil, it is not economically sound to replace the current losses now.

WEED CONTROL

Weeds are often a major problem on irrigated land, especially along the ditch banks and adjacent areas. The irrigation water serves as a carrier for weed seeds, and because the soil is very moist the weeds grow profusely and produce an abundance of seeds. As in other types of farming, weeds on irrigated farms are controlled by cultural and chemical methods.

Annual Weeds

Cultural control.—Since annual weeds grow from seeds each year, the obvious control is to prevent seed formation. Row crops and perennial hay crops help do this; weeds in a row crop are controlled by careful cultivation and those in a hayfield are usually mowed before the seeds form.

Clean cultivation, as in summer-fallowing, is a good way to get rid of weeds. Most soils contain an abundance of seeds, and to eradicate the weeds you must induce the seeds to germinate. Irrigate the land to keep it moist. Destroy each weed crop as it appears and then till the land to turn up another set of seeds for sprouting and eradication.

Chemical control.—Many new selective herbicides have been developed in recent years. When properly applied these selective herbicides have given good results and are recommended. Because new weed chemicals are licensed every year, consult your latest provincial weed-control publication; you may get a copy from your district agriculturist.

Perennial Weeds

Persistent perennial weeds, such as field bindweed, hoary cress, leafy spurge, and Russian knapweed, have reduced the value of many acres of irrigated land. They are not as easy to eliminate as annual weeds; a continuing combination of cultural and chemical control and good cropping practices is necessary to rid your land of them. Learn to recognize them so that you can keep your land from becoming seriously infested.

Cultural control.—As long as food is available in the rootstalks of these perennials the roots continue to send up new shoots. When the new green growth

has been above ground for four or five days, the roots start storing food material again. To control the weeds, therefore, you must cultivate often enough to deplete the root reserves and prevent their replenishment.

Chemical control.—Control small patches of persistent perennials by sterilizing the soil with a herbicide such as sodium chlorate, a chlorate-borate mixture, or monuron, used as recommended by the manufacturer. These chemicals prevent all growth on the treated area for a number of years. Sprays like 2,4-D and MCPA, or the corresponding butyric compounds, help to control the weeds but are unlikely to eradicate them in a single application.

As some chemicals are more effective than others for certain weeds, if possible get competent advice for your problem.

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Ottawa, Ontario

Revision of part of Publication 883,
Irrigation Farming in Southern Alberta
published in 1953

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1962

Cat. No. A53-1152

8M-28858-4:62